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EFFECT OF SOME MINERAL AND ACID FERTILIZERS ON SWEET PEPPER PRODUCTIVITY AND QUALITY UNDER RAS SUDR CONDITIONS.

Almahdy, A. M. and I.M.M. El-Hifny
Desert Research Center

ABSTRACT

The field experiment was carried out in the Experimental Farm of the Desert Research Center at Ras Sudr Region, South Sinai Governorate, during the two successive summer seasons of 2008 and 2009 to study the effect of the combinations among three levels of N, P, K (100%, 80% and 60% of recommended dose) with nitric or phosphoric acids individually or mixture of them to minimizing the harmful effects of salinity on growth, yield and fruit quality of sweet pepper plants. The results suggested that the effect of the highest level of N, P, K (100%) combined with mixture of nitric and phosphoric acids gave the most vigorous plants expressed as plant length, fresh and dry weight of plant and dry matter content of plant, in both seasons. Moreover, it produced the highest fruit yield and gave, the best physical properties of fruits, i.e., fruit length, weigh and number of fruits/plant, as well as the best values of total chlorophyll, vitamin C, N, P, K of leaves tissues. On the other hand, it decreased Na and Cl concentrations.

Keywords: Sweet Pepper, Salinity N, P, K rates, nitric and phosphoric acid application fertigation fertilizers method.

INTRODUCTION

Sweet pepper (*Capsicum annuum* L) is a moderate sensitive plant to salt stress. Salinity is known to affect many aspects of metabolism of plants and induce changes in their anatomy and morphology. Moreover, plants grown in salty conditions come across with two major drawbacks. The first is the increase in osmotic stress due to high salt concentration in soil solution and consequently the decrease in the soil-water potential. The later, is the increase in concentrations of Na^+ and Cl^- and the imbalance in overall concentrations of the ions. In the same respect, Na^+ concentration in roots of sweet pepper plant increased with increasing salinity (Grattan and Grieve, 1999). Sweet pepper is not a salt tolerant vegetable and about 14% of fruit yield loss is resulted by each addition of salt level (1.0S/m) (Yilmaz, 1997).

Among the improvement possibilities, the nutrional requirements play a major role Nitrogen, phosphorus and potassium are the major essential elements required for fertilizing the vegetable plants. Concerning, the application of N, P and K to vegetable crops had a considerable increase in plant growth (Sawan and Rizk, 1998; Singh and Kohl, 1999; AbdEl-Naem *et al.*, 2001; Sivieto *et al.*, 2001, Shafeek, 2003; Aruna *et al.*, 2007)**.** These workers demonstrated that applying of 100% of recommended dose in NPK fertilizer increased the growth, earlier flowering, yield and fruit quality attributes (TSS, acidity content and ascorbic acid) of different vegetable crops. Moreover, El-Beheidi *et al.* (1988) reported that N application at 120 kg/fed. increased fruit yield and fruit quality as compared with N application at 60 or 80 kg/fed. However, K application had no effect on total yield but improved fruit quality. The combination treatments (72 kg K plus 120 kg N) gave the highest fruit yield and quality of sweet melon plant.

Dripirrigation with fertigation provides an effective and cost efficient way to supply water and nutrients to crops. However, less-than optimum management of microirrigation systems may cause inefficient water and nutrient usage, thereby diminishing expected yield benefits and contributing to ground water pollution if water and nitrogen applications are excessive.

Nitrogen and phosphorus are very important nutritional element in metabolic processes, i.e. plant growth, blooming, flower development and total yield. In addition it is role as a main constituent of energy compounds, nucleic acids, phospholipids and co-enzymes. The available of N and P level for plant in Egyptian soil is usually low. Under these conditions, the farmers used to add considerable amounts of mineral N and P fertilizers to face this problem. Leading to the continuous increase in the costs of the chemical fertilizers unabled the farmers to add sufficient quantities of these fertilizers. Thus, it has become essential to use untraditional fertilizers (fertigations) as supplemental or to substitute chemical fertilizers. It might reduce the need for mineral N and P fertilizers beside decreasing the production cost and environment pollution. Qawasmi *et al.* (1999) on sweet pepper plant, Estefanous and Sawan (2003) on okra plant, Mohammad (2004) on squash plant and Rajput and Patel (2006) on onion plant reported that 40 kg N/fed. applied as nitric acid solution significantly enhanced shoot dry weight, fruit fresh and dry weights and fruit yield as well as N and P uptake.

Most Egyptian soils are alkaline in reaction where soil pH surpasses 7. In spite of the huge additions P fertilizers to cultivated soils the available P level for plants is usually low, since it rapidly converts to unavailable form and this becomes inaccessible by plants (Mahmoud and AbdEl-Hafez, 1982). Phosphoric acid (H_3PO_3) which is the primary source of P for plants (Ouimette and Coffey, 1989) and Selim *et al.* (2009) indicated that the application of P (phosphoric acid) markedly increased the available P concentrations in soil and plant tissues and increased plant growth and yields. In the same respect, phosphoric acid has useful properties in agriculture (Forster *et al.*, 1998).

The present work aimed to investigate the effect of nitric and phosphoric acid at some levels of application as fertigation on sweet pepper productivity under salinity stress.

MATERIALS AND METHODS

The present work was carried out during the two successive summer seasons 2008 and 2009 at Experimental Farm of Desert Research Center at Ras Sudr Research Station, in South Sinai Governorate. The soil was highly calcareous and saline irrigated by drip irrigation system. The physical and chemical analyses of the experimental soil are presented in Tables (A and B). The chemical analysis was carried out according to the methods described by Piper (1950) and Chapman and Pratt (1961) respectively, while the chemical analysis of irrigation water is given in Table (C).

Table (A): Mechanical properties of the experimental soil.

Depth (cm)	$CaCO^3$ %	Coarse sand (1-0.4 mm)	Fine sand (0.25-1 mm)	Silt (0.05-0.002 mm)	Total sand (0.1-1)	Clay (0.002)	Class texture
0-30	56.99	53.68	27.60	8.05	81.28	19.79	Sandyloam
30-60	52.48	23.74	62.34	7.59	86.08	6.33	Sandyloam

Table (B): Chemical analysis of the experimental soil.

Saturation soluble extract										
Depth (cm)	pH	Ec dS/m^2	Soluble anions (meq/100g)				Soluble cations (meq/100g)			
			CO_3	HcO_3	So_4	Cl	Ca	Mg	Na	K
0-30	7.7	4.77	0.00	6.00	10.50	31.20	24.00	11.00	10.52	2.18
30-60	7.4	4.16	0.00	3.00	16.10	22.50	16.83	6.00	17.80	0.09

Table (C): Chemical analysis of the irrigation water.

Salinity (ppm)	pH	Ec dS/m^2	Soluble anions (meq/100g)				Soluble cations (meq/100g)			
			CO_3	HcO_3	SO_4	Cl	Ca	Mg	Na	K
3500	8.4	5.47	0.00	2.50	81.23	16.22	23.65	19.18	56.66	0.51

Seeds of sweet pepper (*Capsicum annuum* L.) c.v. Calfornia Wonder, were sown in nursery on February 10 in both seasons. Transplants were set up into the field 50 days after sowing, at one side of irrigation lines, 30 cm apart between plants. The irrigation line length was 14m and the distance between lines was 75 cm.

The experimental treatments:

A- Mineral fertilizers (NPK) were applied as:

1- 100% NPK (300 kg/fed. N (20.5%) as ammonium sulphate 300 kg/fed. P_2O (15%) as calcium supper phosphate and 200 kg/fed. K_2O (48%) as potassium sulphate).

2- 80% NPK.

3- 60% NPK.

B- Mineral acids:

1- Nitric acid (60%) was added after 3 weeks from transplanting and weekly until the harvest time.

2- Phosphoric acid (80%) as the previous system of nitric acid.

3- Combination of nitric acid plus phosphoric acid.

All mineral acids were added weekly as fertigation through drip irrigation lines.

Calcium supper phosphate (300 kg/fed.) was added at one month before transplanting, while ammonium sulphate (300 kg/fed.) and potassium sulphate (200 kg/fed.) were added twice after three and six weeks after transplanting.

A split plot design with four replicates was used. The mineral fertilizers were situated at the main plots while the sub plots represented mineral acids. The experimental unit area was 10.5 m^2 (14m length of irrigation line and 0.75m between lines.

Recorded data:

A- Vegetative growth:

Three plants of each plot were chosen randomly at 90 days after plant height, fresh and dry weight of plant, and dry matter.

B- Fruit yield and quality:

Pepper fruits were harvested twice every week and the fruit length number of fruits/plant, average fruit weight and total yield were calculated.

C- Chemical content:

Sample of fruits were taken at harvesting time and ascorbic acid (vitamin C) was determined according to A.O.A.C. (1995). Total nitrogen was determined by method according to Huphries (1965). Determinations of K and Na were carried out using a flamephotometer according to the methods of Brown and Lilland 1946), chloride was also determined by methods described by Richards (1954). Phosphorus determination method depended on the formation of a blue complex between ammonium molybdate in the presence of ascorbic acid (reducing agent) according to Rowell (1993).

Statistical analysis:

All obtained data were subjected to the pepper statistical analysis of variances of the split plot design according to the procedure outlined by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

1- Growth characters:

a) Effect of NPK fertilizers:

Data in Table (1) showed that the vegetative growth of pepper plants was increased by increasing NPK level up to its highest level (100% NPK). Plant length, fresh and dry weight values were significantly the highest by the application of the highest NPK level. Dry matter percent was not significantly affected by the tested NPK levels. The increase in the vegetative growth of pepper plants due to the highest NPK levels might be referred to its favourable role in increasing the availability of nutrients to plant absorption and higher photosynthetic activity (Mengel and Kirkby, 1978). This increment in vegetative growth of pepper plants by may be due to the role of nitrogen on the synthesis of plant proteins, chlorophyll and enzymes and the role of phosphorus on root growth, phosphoproteins, phospholipids and ATP, ADP formation. Also, may be due to the role of potassium on promotion of enzyme activity and enhancing the translocation of assimilates and protein synthesis (Devlin and Withan, 1986). Many investigators came to similar results (Sawan and Rizk, 1998; Singh and Kohl, 1999; El-Desuki *et al.,* 2000; AbdEl-Naem *et al.*, 2001; Sivieto *et al.,* 2001; Shafeek, 2003; Aruna *et al.,* 2007).

b) Effect of mineral acids:

The nutrition mixture of nitric and phosphoric acids added weekly as fertigation through drip irrigation lines gained a significantly effect on all plant growth parameters compared to individual nutrition (Table 1). Pepper plants which received this mixture resulted in the best vigor, i.e. the tallest plant, heaviest fresh and dry weight as well as the highest dry matter %.

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It could be concluded that fertigation pepper plants by nitric and (or) phosphoric acid caused a good growth parameters if compared with that plants which had no fertigation (control). These findings were true in both seasons. The increase in the values of plant growth characters of pepper plant may be attributed to the availability of nitrogen and phosphorus in the root zone which reflected on the growth of plant. Our findings are in agreement with those reported by Mahmoud (1995), Qawasmi *et al.* (1999), Estefanous and Sawan (2003), Chapagainh *et al.* (2003), Rizk *et al.* (2003), Mohammed (2004), Rajput and Patel (2006), Selim *et al.* (2009) and Badr *et al.* (2010).

c) Effect of the interaction between NPK and mineral acid fertilizers:

The combined effect of NPK and mineral acid fertilizer on vegetative growth of pepper plants is shown in Table (1). There were no significant effects for the interaction of NPK and mineral acid fertilizers on the studied plant growth characters, except plant fresh weight in the second season.

2- Fruit yield and quality:

a) Effect of NPK fertilizers:

Data in Table (2) showed that total yield and its components (fruit number, length and weight) were significantly increased with increasing the level of NPK application. The highest values were obtained by the application of the recommended level. However, these results were similar in the two seasons of the experiment. These increases may be due to favourable effect on the vegetative growth (Table 1). These results agree with those reported by El-Beheidi *et al.* (1988), Damarany and Farag (1994). Sivieto *et al.* (2001), Shafeek (2003) and Aruna *et al.* (2007).

b) Effect of mineral acids:

The obtained data showed that both individual mineral acids and mixture of them had an enhancement influence on in fruit yield and its components compared with that control. The presented data revealed that application of mixture of nitric and phosphoric acid resulted in the heaviest pepper fruit yield, the highest values of number of fruits, weight of fruit and fruit length. These findings were in harmony for both seasons. It can be concluded that mineral acids fertigation have good effect in increasing the yield and lower N rates would be adequate to produce higher yield, thus lowering fertilizeration cost and minimizing environmental impact of over fertilization, Mohammed (2004). These results agree with those reported by Qawasmi *et al.* (1999), Estefanous and Sawan (2003), Chapagainh *et al.* (2003), Rizk *et al.* (2003), Rajput and Patel (2006), Selim *et al.* (2009) and Badr *et al.* (2010).

c) Effect of the interaction between NPK and mineral acids fertilizers:

The combined effect of the NPK and mineral acid fertilizers increased total yield and its components of sweet pepper plant as shown in Table (2). Increases in total yield and average fruit weight were significant but number of fruits and fruit length did not reach the level of significancy. These results were similar in the two seasons. These increases were the function of increases in the vegetative growth, photosynthetic activity, dry matter accumulation and NPK content (Mohammed, 2004).

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3- Chemical composition:

a) Effect of NPK fertilizers:

Data in Table (3) showed that nutritional values of fruit contents of total chlorophyll, ascorbic acid, nitrogen, phosphorus and potassium were significantly increased with increasing level of NPK application as shown in both seasons. In the same respect, application of the highest level of NPK (100% of recommended dose) significantly increased all the chemical fruit contents (total chlorophyll, ascorbic acid, nitrogen, phosphorus and potassium) compared to the medium (80%) or low level (60% of recommended dose). On the other hand, the highest level of NPK (100% of recommended dose) significantly decreased Na and Cl contents in pepper leaf tissues. Consquently, absorption would be higher and nutrient accumulation in plant tissues increases (El-Desuki *et al.,* 2000). These results agree with those reported by El-Beheidi *et al.* (1998), Sivieto *et al.* (2001), Shafeek (2003) and Aruna *et al.* (2007).

b) Effect of mineral acids:

The application of nitric and phosphoric acids as individual or mixture for pepper plants resulted in more nutritional values, i.e. total chlorophyll, ascorbic acid, N, P and K in plant tissues if compared to without application (Table 3). Moreover, that plants which treated with the mixture of nitric and phosphoric acids resulted in the best nutritional values in comparison with that plants received the individual acid. These results were similar in the two seasons. On the other hand, the mixture of nitric and phosphoric acids significantly decreased Na and Cl contents in pepper leaves tissues. It could be concluded that fertigation with the mixture of nitric and phosphoric acids for pepper plant had an enhancement in the chemical constituents of pepper fruits. This might be attributed to the role of each N and P in plant metabolism which reflected on the total fruit yield and its properties. Many authors studied the response of vegetable fruit yield to the application of nitric or phosphoric acid and their reports are in good accordance with the which obtained here (Qawasmi *et al.,* 1999; Estefanous and Sawan, 2003; Chapagainh *et al.,* 2003; Rizk *et al.,* 2003; Mohammed, 2004; Rajput and Patel, 2006; Selim *et al.,* 2009; Badr *et al.,* 2010).

c) Effect of the interaction between NPK and mineral acid fertilizers:

The interaction within the application of NPK levels and fertigation with nitric or phosphoric acids indicated that the N and K values were significantly increased in both experiments by the application of NPK combined mineral acids. The highest values were detected with application of NPK (100% recommended dose) combined with mixture of nitric and phosphoric acids. These results were true in the two experimental seasons. However, the no significant effect of the interaction on chlorophyll P, Na, Cl and ascorbic acid was found, this might be attributed to that the two interaction factors acted independently.

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تـأثير بعض الأسمدة والأحمـاض المعدنيـة علـى إنتاجيـة وجـودة الفلفل الحلـو تحت ظروف منطقة رأس سدر

أحمد محمد المهدي و إصلاح محمد محمد الحفني
مركز بحوث الصحراء

تعتبر منطقة رأس سدر من الأراضي القلوية المتأثرة بالملوحة إلى حد كبير، ونظرًا لقلة كفاءة امتصاص أغلب العناصر الضرورية لنمو النبات مع ارتفاع الملوحة للتربة ومياه الري مما يقلل من إنتاجية النبات، وعلى ذلك فإن استخدام الطرق الحديثة للري واستخدام التسميد مع الري ربما يقلل من التأثير الضار للملوحة، هذا وقد أجريت تجربة حقلية في محطة تجارب رأس سدر (مركز بحوث الصحراء) محافظة جنوب سيناء في صيف موسمي ٢٠٠٨ و ٢٠٠٩ لمحاولة تقليل الأثر الضار لملوحة الأرض ومياه الري وذلك بدراسة تأثير التفاعل بين التركيزات المختلفة من عناصر النيتروجين والفوسفور والبوتاسيوم (١٠٠% أو ٨٠% أو ٦٠% من السماد الموصى به) مع التسميد بنوعين من الأحماض المعدنية (حمض النتريك أو حمض الفوسفوريك أو مخلوط منهما من خلال النقاطات الموجودة بخراطيم الري) وتأثير ذلك على نمو ومحصول وجودة ثمار الفلفل الحلو. وقد أظهرت النتائج أن تسميد نباتات الفلفل الحلو صنف كاليفورنيا وندر بالتركيزات العالية من النيتروجين والفوسفور والبوتاسيوم (١٠٠% من الموصى به) مع إضافة مخلوط من حمض النتريك والفوسفوريك قد أعطى أكبر نمو خضري للنباتات متمثلاً في طول النبات والوزن الطازج والجاف ونسبة المادة الجافة للنباتات وكذلك أعلى محصول متمثلاً في المحصول الكلي للفدان وكذلك عدد ووزن للثمار وطول الثمرة بالإضافة لمحتوى الثمار من الكلوروفيل وفيتامين ج والنيتروجين والفوسفور والبوتاسيوم بينما قل محتوى الثمار من عنصري الصوديوم والكلوريد.

قام بتحكيم البحث

أ.د / هالة عبد الغفار السيد	**كلية الزراعة – جامعة المنصورة**
أ.د / محمد رضا شفيق	**المركز القومي للبحوث**

Table (1): Effect of NPK and nitric, phosphoric acids on growth characters of sweet pepper during summer of 2008 and 2009 seasons.

NPK rates	Comp.	Season 1 Plant Length (cm.)	Season 1 Weight/ Plant (g) Fresh	Season 1 Weight/ Plant (g) Dry	Season 1 Dry matter (%)	Season 2 Pant length (cm)	Season 2 Weight/ Plant (g) Fresh	Season 2 Weight/ Plant (g) Dry	Season 2 Dry matter (%)
NPK 100%	Control	41.10	313.20	57.14	18.24	39.83	296.10	52.87	17.86
	Nitric A.	44.10	332.10	67.85	20.43	41.58	308.73	62.72	20.32
	Phos. A.	42.55	319.00	70.00	21.94	41.90	301.53	66.36	22.01
	N.A.+P. A.	46.45	337.53	79.25	23.48	45.50	321.58	74.34	23.12
Mean		**43.55**	**325.46**	**68.56**	**21.02**	**42.20**	**306.98**	**64.07**	**20.83**
NPK 80%	Control	38.50	283.88	49.21	17.34	37.50	271.65	47.36	17.44
	Nitric A.	40.75	317.28	62.85	19.81	39.90	298.00	28.17	19.52
	Phos. A.	39.65	289.83	62.46	21.55	38.80	279.90	58.09	20.76
	N.A.+P. A.	42.55	302.43	73.76	24.98	41.20	305.23	68.13	22.32
Mean		**40.36**	**298.35**	**62.07**	**20.92**	**39.35**	**288.69**	**57.94**	**20.01**
NPK 60%	Control	36.80	252.10	40.37	16.02	36.10	252.38	46.44	18.39
	Nitric A.	38.65	257.58	53.74	21.62	37.80	28060	52.93	18.87
	Phos. A.	37.15	264.73	54.38	20.55	36.90	261.53	52.64	20.13
	N.A.+P. A.	40.15	292.23	63.46	21.72	39.80	289.83	64.42	22.23
Mean		**38.19**	**266.66**	**52.99**	**19.98**	**37.65**	**271.08**	**54.11**	**19.00**
Averages	Control	38.80	283.06	48.91	17.20	37.81	273.38	48.89	17.00
	Nitric A.	41.17	302.32	61.48	20.62	39.76	295.78	57.94	19.57
	Phos. A.	39.78	291.18	62.28	21.35	39.20	280.98	59.03	20.97
	N.A.+P. A.	43.05	310.73	72.16	23.39	42.17	305.54	68.96	22.56
L.S.D. at 5%	NPK	1.41	17.34	1.25	N.S.	0.54	1.45	3.36	N.S.
	Mineral acids.	1.26	17.33	1.44	1.76	1.04	1.77	3.07	1.10
	Interactions	N.S.	N.S.	N.S.	N.S.	N.S.	3.07	N.S.	N.S.

Table (2): Effect of NPK and nitric, phosphoric acids on yield and its components of sweet pepper during summer of 2008 and 2009 seasons.

NPK rates	Comp.	Fruit (season 1)			Yield (ton/fed.)	Fruit (season 2)			Yield (ton/fed.)
		No./ plant	Average Wt. (g)	Length (cm)		No./ plant	Average Wt. (g)	Length (cm)	
		Season 1				Season 2			
NPK 100%	Control	12.10	29.80	3.80	3.26	12.80	30.90	3.60	3.57
	Nitric A.	15.60	52.40	5.80	7.34	17.10	51.10	5.70	7.86
	Phos. A.	19.50	49.50	5.30	8.68	20.80	49.40	5.30	9.24
	N.A.+P. A.	21.20	56.30	6.30	10.75	23.00	55.50	6.20	11.48
Mean		17.10	47.00	5.30	7.51	18.43	46.73	5.20	8.04
NPK 80%	Control	11.90	25.00	3.50	2.70	12.00	28.10	3.30	3.04
	Nitric A.	15.00	48.80	5.40	6.60	16.10	46.80	5.10	6.78
	Phos. A.	17.10	44.80	4.80	6.92	18.20	43.60	4.60	7.15
	N.A.+P. A.	19.10	50.00	6.00	8.58	20.40	49.30	5.80	9.05
Mean		**15.78**	**42.15**	**4.93**	**6.20**	**16.68**	**41.95**	**4.70**	**6.50**
NPK 60%	Control	9.80	23.40	3.10	2.08	10.50	25.80	3.00	2.44
	Nitric A.	14.50	40.30	5.00	5.27	15.10	38.30	4.80	5.20
	Phos. A.	16.80	38.20	4.20	5.80	17.30	36.70	4.00	5.70
	N.A.+P. A.	18.30	46.90	5.50	7.75	19.50	45.20	5.10	7.93
Mean		**14.85**	**37.20**	**4.45**	**5.23**	**15.60**	**36.50**	**4.23**	**5.32**
Averages	Control	11.27	26.07	3.47	2.68	11.77	28.27	3.30	3.02
	Nitric A.	15.03	47.17	5.40	6.40	16.10	45.40	5.20	6.61
	Phos. A.	17.80	44.17	4.77	7.13	18.77	43.23	4.63	7.37
	N.A.+P. A.	19.53	51.07	5.93	9.03	20.97	50.00	5.70	9.48
L.S.D. at 5%	NPK	0.84	2.71	0.08	0.47	0.08	0.88	0.32	0.17
	Mineral acids.	0.81	1.18	0.32	0.37	0.84	1.03	0.31	0.35
	Interactions	N.S.	2.04	N.S.	0.64	N.S.	1.79	N.S.	0.60

Table (3): Effect of NPD and nitric, phosphoric acids on chemical composition of sweet pepper during summer of 2008 and 2009.

NPK rates	Mineral acids.	2008 Total chloro-phyll	2008 Ascorbic acid (mg/100 gm)	2008 % N	2008 % P%	2008 % K%	2008 % Na%	2008 % C1	2009 Total Chloro-phyll	2009 Ascorbic acid (mg/100 gm)	2009 % N	2009 % P	2009 % K	2009 % Na	2009 % C1
		Season 1							Season 2						
NPK 100% Mean	Control	21.90	66.00	2.15	0.28	2.39	2.10	3.21	23.32	64.00	2.10	0.30	2.36	1.97	3.2
	Nitric A.	24.45	90.00	3.08	0.37	2.50	2.05	3.15	26.02	88.00	3.12	0.40	2.61	1.95	2.96
	Phos. A.	23.85	78.00	2.97	0.42	2.53	2.00	3.08	25.50	72.00	3.00	0.46	2.62	1.90	2.88
	N.A.+P. A.	30.00	115.00	3.82	0.53	3.30	1.86	2.86	32.40	110.0	3.94	0.58	3.49	1.75	2.66
Mean		**25.05**	**87.25**	**3.01**	**0.40**	**2.68**	**2.00**	**3.08**	**26.81**	**83.50**	**3.04**	**0.44**	**2.77**	**1.89**	**2.88**
NPK 8%	Control	20.25	60.00	1.87	0.21	2.20	2.19	3.37	21.52	59.00	1.89	0.23	2.28	1.74	2.64
	Nitric A.	22.65	88.00	2.88	0.30	2.39	2.14	3.29	24.30	87.00	2.91	0.33	2.49	2.00	3.02
	Phos. A.	22.50	70.00	2.56	0.34	2.41	2.10	3.23	24.00	69.00	2.58	0.37	2.50	1.99	3.02
	N.A.+P. A.	26.70	110.00	3.31	0.44	3.00	2.02	3.11	28.65	110.0	3.38	0.48	3.18	1.91	2.90
Mean		**23.03**	**82.00**	**2.66**	**0.32**	**2.50**	**2.11**	**3.25**	**24.62**	**81.25**	**2.69**	**0.35**	**2.61**	**1.91**	**2.89**
	Control	19.60	28.00	1.68	0.19	2.08	2.28	3.51	20.25	56.00	1.71	0.20	2.17	2.15	3.26
	Nitric A.	21.00	82.00	2.23	0.25	2.18	2.21	3.40	22.35	80.00	2.30	0.27	2.28	2.09	3.17
	Phos. A.	20.77	62.50	2.05	0.28	2.22	2.15	3.31	22.12	63.00	2.10	0.31	2.30	2.04	3.10
	N.A.+P. A.	24.15	101.50	2.78	0.40	2.78	2.06	3.17	22.80	100.0	2.90	0.44	2.88	1.95	2.96
Mean		**21.38**	**76.00**	**2.19**	**0.28**	**2.32**	**2.18**	**3.35**	**21.38**	**74.75**	**2.25**	**0.31**	**2.41**	**2.6**	**3.12**
Averages	Control	20.58	61.33	1.90	0.23	2.22	2.19	3.36	21.70	59.67	1.90	0.24	2.27	1.95	2.97
	Nitric A.	22.70	86.67	2.73	0.31	2.36	2.13	3.28	24.22	85.00	2.78	0.33	2.46	2.01	3.05
	Phos. A.	22.37	70.17	2.53	0.35	2.39	2.08	3.21	23.87	68.00	2.56	0.38	2.47	1.98	3.00
	N.A.+P. A.	26.95	108.83	3.30	0.46	3.03	1.98	3.05	28.95	106.7	3.41	0.50	3.18	1.87	2.84
L.S.D. at 5%	NPK	0.65	1.31	0.004	0.03	0.04	0.01	0.02	1.68	2.41	0.08	0.02	0.05	0.13	0.20
	Mineral acids.	1.53	3.47	0.05	0.02	0.03	0.02	0.03	1.55	2.03	0.04	0.02	0.02	N.S.	N.S.
	Interactions	N.S.	N.S.	0.08	N.S.	0.05.	N.S.	N.S.	N.S	N.S.	0.07	N.S.	2.03	N.S.	N.S.